

On the requirements of waveforms and systems for use in joint communications and radar operation

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Agenda

High Level Technical Overview

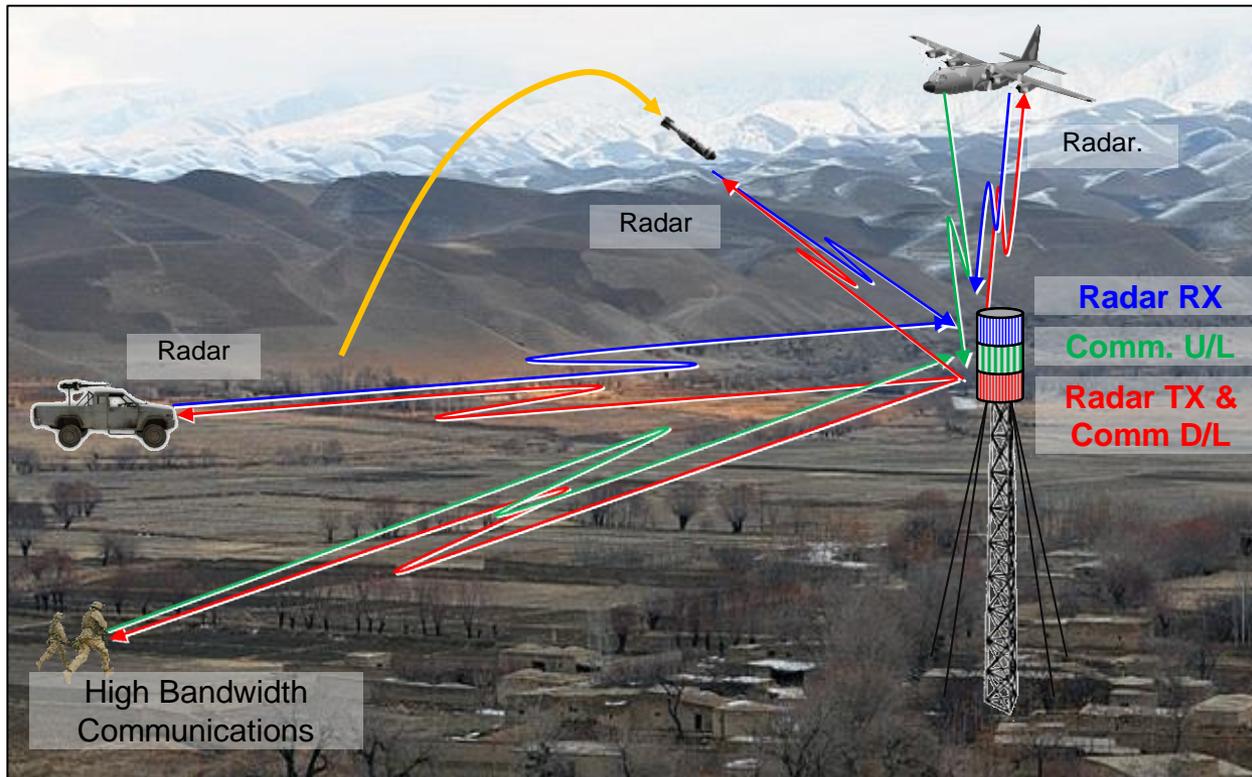
- COMMDAR – The joint communications and radar system
- Waveform
 - Requirements for radar
 - Requirements for communications
 - Common requirements
- MIMO
 - Communications
 - Radar

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COMMDAR System Overview

- Fixed site COMMDAR installation
- Joint radar and downlink communication waveform
- Uplink communication on separate frequency (FDD)

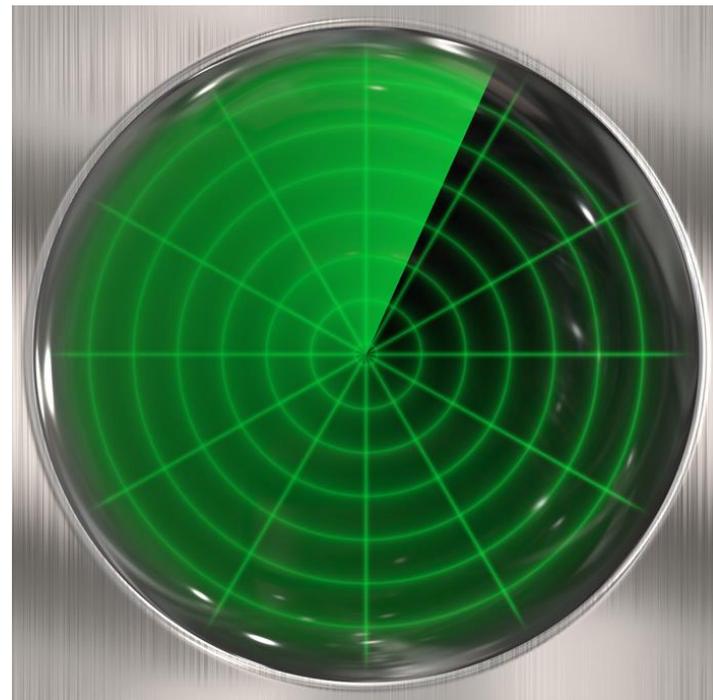




Waveform Requirements for Radar

- Spectral Leakage
- Computational Complexity
- Range/Doppler Sidelobes
- Clutter Suppression
- Energy on Target
- Range Resolution
- Doppler Resolution
- No Waveform Ambiguities

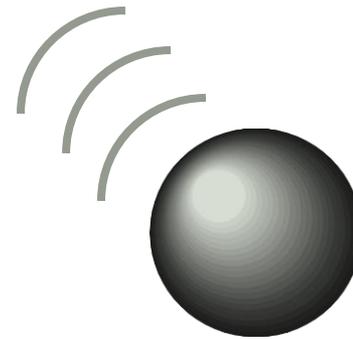
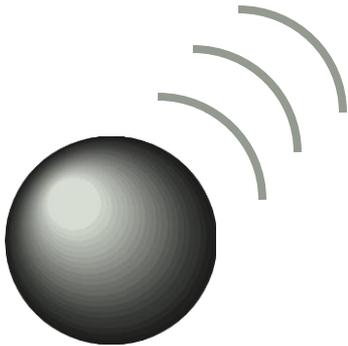
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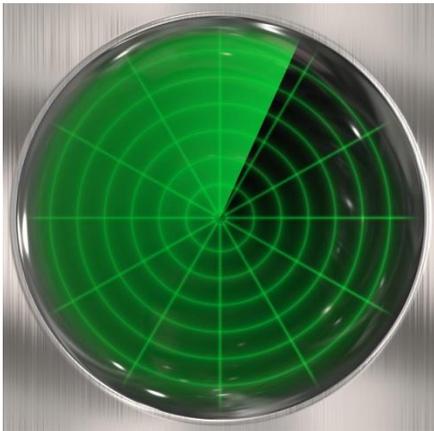
Waveform Requirements for Comms

- Spectral Leakage
- Computational Complexity
- Data Rate and Spectral Efficiency
- Synchronization/Training Required
- Network Control Required
- Ability to Meet Quality of Service Requirements

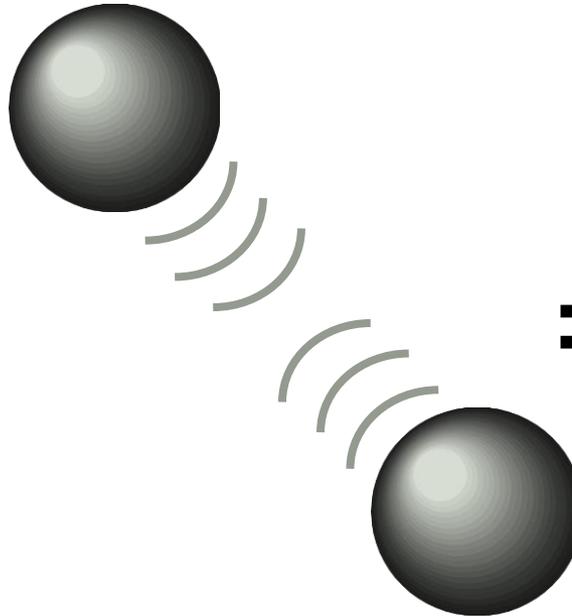




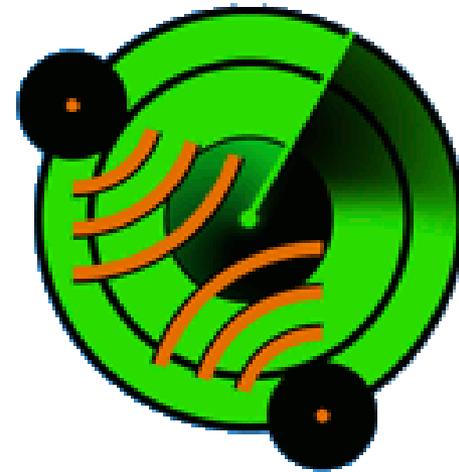
COMMDAR = Communications & Radar



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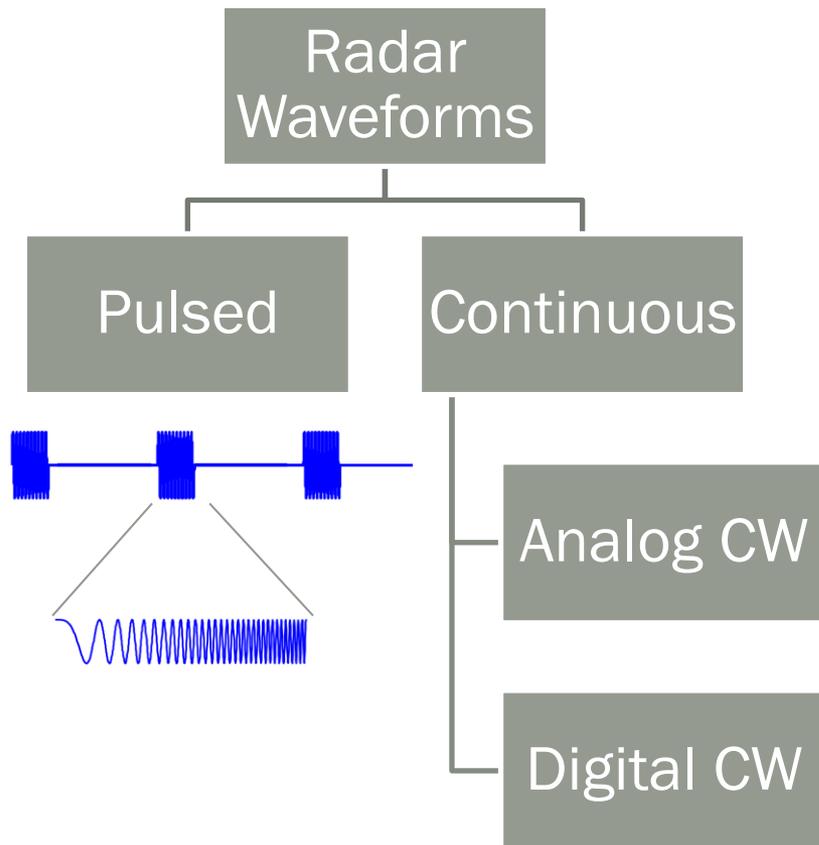
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Joint Waveform Requirements

- Spectral leakage
- Computational complexity
- Peak to average power ratio





Fundamental Differences

- Radar is typically SNR limited
- Communications either SNR or bandwidth limited
- Radar waveforms are typically pulsed
- Communications are typically continuous

Communications:

$$C = B \log(1 + SNR)$$

Only Comms has
bandwidth

Radar:

$$R_{max} = \sqrt[4]{\frac{P_{avg} G_t A_r \sigma T_{int}}{(4\pi)^2 SNR N_0}}$$

Both have SNR



Waveform Requirements Tradeoff

Waveform Degrees of Freedom	Communications Metrics						Radar Metrics					
COMMDAR Choice												

Benficial No / Mixed Affect Detrimental

- Analyze multiple waveforms
 - Pulsed vs. continuous
 - Waveform modulation: OFDM, DSSS, Single Carrier,...
 - Multiuser access: TDMA, CDMA,...
 - MIMO
 - Etc.



Conflicts in Conventional Waveforms



Maximizes data rate

- Phase and amplitude modulation
- Tolerant of high PAPR
- High modulation order when SNR allows

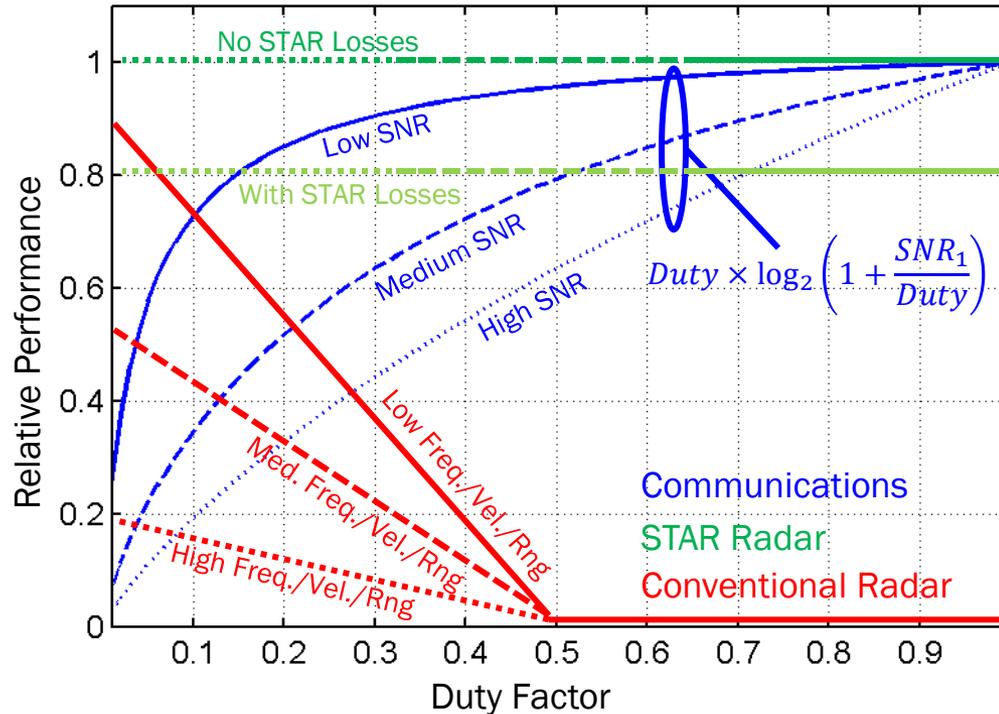
Maximizes SNR/Power

- Phase or frequency modulation
- Intolerant of high PAPR
- Typically low modulation order or analog modulation

Focus on maximizing radar energy on target



100% Duty Factor is Good for Both



- Pulsed waveform radar performance degrades with increasing duty factor while comms. performance degrades with decreasing duty.
- Simultaneous transmit & receive (STAR) enables high-duty factors to work well for radar. COMMDAR goal is 100% duty factor waveform.
- Both continuous and pulsed waveforms will be compared.



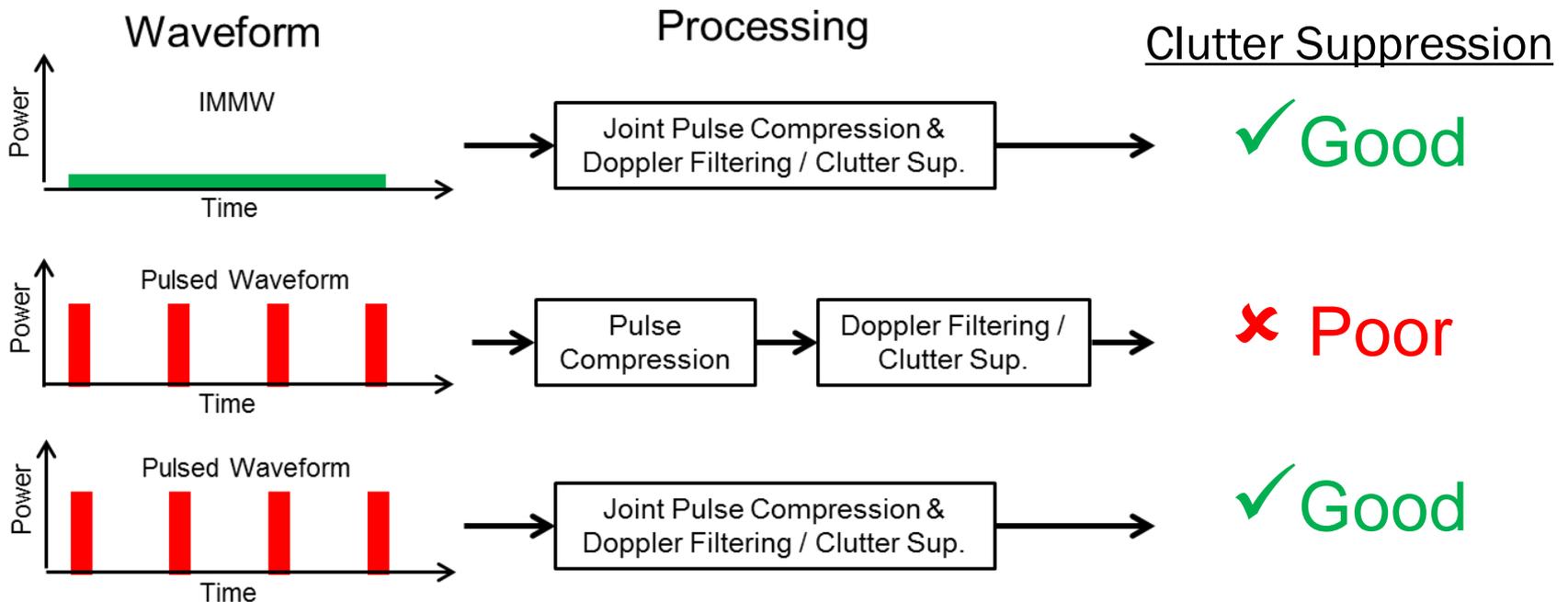
Computational Complexity

Radar

- Filtering out interference

Communications

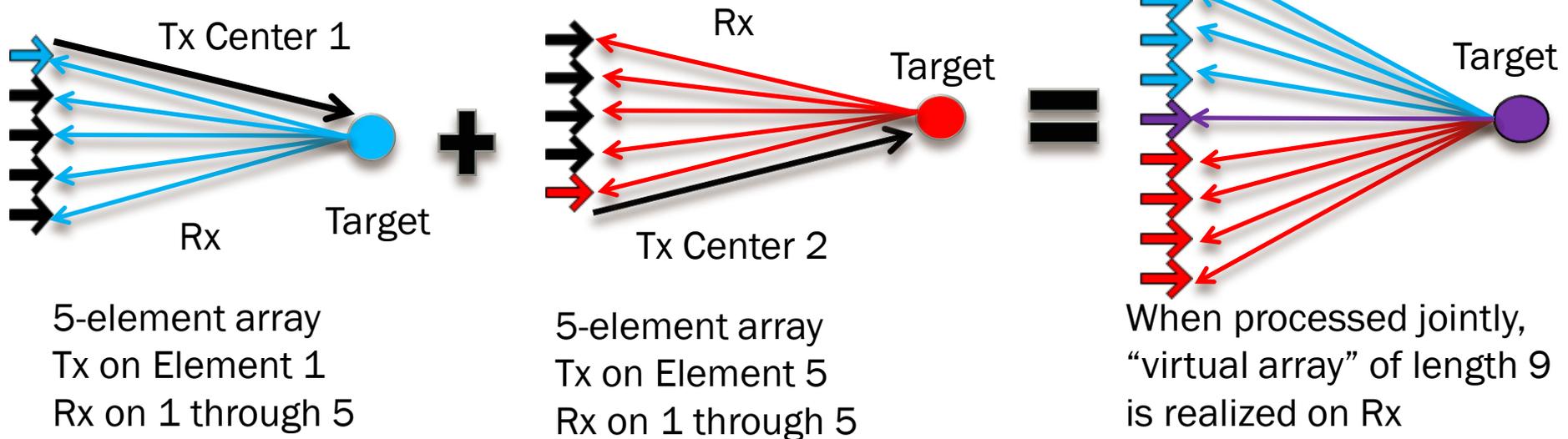
- Channel equalization





MIMO Radar

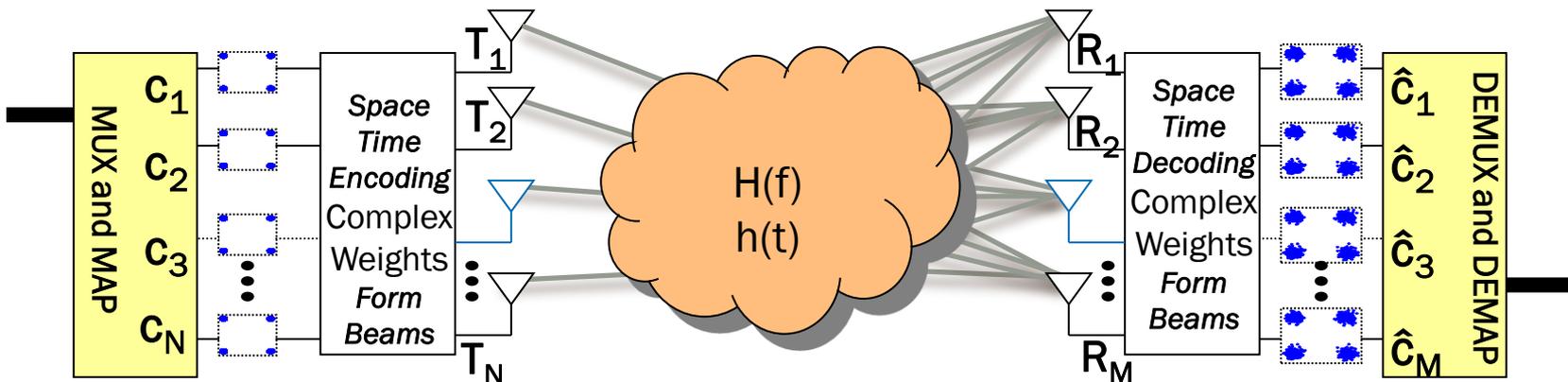
- Radar MIMO is a technique to achieve improved performance from a phased array
- Benefits of MIMO radar:
 - Improved angular resolution and accuracy
 - Reduced physical size (and cost) for a given beamwidth
 - The most severe multi-path fades are reduced due to phase diversity





MIMO Requirements

- MIMO COMMS → High rank channel matrix
 - Allows for high correlation between waveforms
- MIMO RADAR → Lower rank channel matrix
 - Requires low cross-correlation properties in space-time codes





Summary

- COMMDAR: Joint downlink communications and radar waveform
- Waveform requirements
 - Fundamental differences
 - What is good for both radar and communications → 100% duty factor
 - Peak to average power ratio is more critical for radar operations
- MIMO
 - MIMO COMMS → High rank channel matrix
 - MIMO RADAR → Lower rank channel matrix





Questions?